Preface

A gene has four characteristics as replication, mutation, evolution, and uniqueness. The human body is very complex, and a gene can be used to diagnose health problems. The economic system is very complex too; is there something like a gene in the economy? It has been found that production function with electricity in electricity economics has the four characteristics of a gene.[1]

Electricity plays a crucial role in the economic activities because it is widely used for commercial purposes, in agriculture, industry, and our daily life. It is clear that the more output of production, the more electricity must be used in the production. Thus, there is a positive correlation between electricity use and production output. On the other hand, electricity data can serve as an accurate measure for economic productions in nearly all kinds of economic activities since there are many meters measuring the electricity from the power generation side to demand side. The electric power data has the features of real time, reliability, accuracy, comprehensiveness, and the synchronism with economic activity. And also, it is very easy to get these data. A mechanism of collecting power (power generation, power consumption) data has been established in China, which ensures that the electric power data can be obtained accurately and reliably every month.

Production function with electricity, putting electricity as a representative production factor, has been studied in electricity economics.[2] Millions of production functions with electricity from a firm's level, to sectoral level, to industrial level, and to national economy level can form a gene mapping of the economy. Economic gene mutations on the four levels can depict the big changes of the marginal representative factor productivity in the economy, and it can be used to diagnose the economic problems.

[1] Zheng Hu and Zhaoguang Hu (2013), "Production function with electricity consumption and its applications" [J], *Energy Economics* (39, 171–192)

[2] Zhaoguang Hu and Zheng Hu (2013), *Electricity Economics: Production Functions with Electricity* [M], Springer

In this book, all these concepts are introduced in detail, and they are applied to review China's economy. We hope that readers can have a deep view and diagnose the economy for other countries from the perspective of gene mutations.

In order to simulate the operation of China's economy, authors proposed the Agents Response Equilibrium (ARE) model after studying the strengths and weaknesses of Computable General Equilibrium (CGE) model and Agent-Based Computational Economics (ACE) model. The ARE model is developed on the basis of the multi-agent technique. Authors build the intelligent agent model with 42 sectors in the input-output table of China. As agents, they have their goal, knowledge base, learning ability, the capability to communicate with others, and decision making on their business. Besides, the overall economic activities of the agents, interaction mechanism, and markets are designed according to the economy in China. Then, it can be used to simulate the operation of the national economy and conduct certain policy experiments. Based on the input-output table and some assumptions of fiscal and monetary policies, the economic activities can be simulated and result in new input-output tables and prices of the products of the 42 sectors year by year. Thus, it is easy to study the impacts of the policies, just like playing games on a computer. China's economy has been simulated from 2008 to 2014 to verify the accuracy and reliability of the ARE model, while the simulation from 2015 to 2025 serves as the economic development with the results of input-output tables. It is also the foundation to extend the research on economic gene mutations in China.

This book can be divided into three parts. The first part describes the concepts and applications of electricity economics and analyzes the gene mutations and gene mapping in China's economy. It contains three chapters. In Chap. 1, a typical theory of electricity economics is introduced, and economic development in China is analyzed from the perspective of electricity economics. In Chap. 2, electricity and energy supply in China is reviewed, and the concept of mutation is expressed through case studies in the USA, Japan, and China. Chapter 3 presents the concept of gene mapping and studies the situation in China until 2025 in both business as usual scenario and policy scenario. The second part introduces our ARE model which acts as the economic simulation tool for policy study. It consists of four chapters. In Chap. 4, economic modeling techniques that are widely used and discussed nowadays are reviewed. In Chap. 5, the basic content of intelligent engineering is introduced. In Chap. 6, the foundations, framework, features, and the overall design of the ARE model are introduced. In Chap. 7, each kind of agent in the ARE model is described one by one, and some details about our computer program are shown. The third part acts as the verification of the ARE model and presents some simulation results such as the annual input-output tables. Three chapters are included in this part. In Chap. 8, the simulation results of China's economy during the period of 2008–2010 are analyzed, while Chap. 9 focuses on the simulation from 2011 to 2014. In Chap. 10, all the annual input-output tables of China in 2011–2025 obtained by our simulation are listed, since they are very useful data foundation to conduct various researches but mostly not available by published materials.

The authors are the delegates of our team that has been committed in the area of economic modeling by intelligent agents since 2003. As the team leader, Prof. Zhaoguang Hu studies and directs the process of research in detail. Typically, principal ideas in this book are mostly proposed by him. Dr. Jiahai Yuan is the first member of the team to study the intelligent agent theory. He learned a lot about the multi-agent system and introduced this theory to our team. He began to try to apply this technique to the modeling and simulation of the economic system, especially the electricity market. Dr. Minjie Xu summarized the methodology of intelligent engineering and developed the generalized model in the intelligent space. He utilized the agent-based model to simulate residential electric power consumption and the impacts of macroeconomic policies on electricity consumption. The electricity price, income level, and government expenditure can be simulated to observe the influences. Dr. Meng Li carried out the analysis and empirical study of electric power supply and demand systematically. Through the discovery of the quantitative relationship between electrical load rate and coal consumption, he developed the simulation and analysis model to research the influences of relevant policies. Dr. Xiandong Tan studied the input-output table updating approach using electricity data. He also participated in the design of response rules of sector agents, government agent, and resident agent and the software system of multi-agent model. Besides, he executed the simulation of the demand side management compensation mechanism in China. Dr. Xiaoyou Jiao explored the theory extension from system engineering to intelligent engineering. A modified intelligent inference model to deal with the analysis of complicated issues was proposed by him. He executed the intelligent simulation of the influences of macroeconomic policy on electricity consumption. Dr. Jianwei Tian creatively integrated intelligent engineering theory and multi-agent modeling technology. His applications focused on the simulation of smart grid operation. He put forward an agent-based hierarchical hybrid coordination model and algorithm to simulate the grid-consumer interoperability among related stakeholders under smart grid framework. Dr. Xiao Xiao started to build a multi-agent system model that was a complex giant system which contains control agents, coordinate agents, and functional agents, in order to reflect the production, exchange, distribution, consumption, etc. in the economic system. By means of the multi-agent model, he attempted to simulate the asymmetric effects of the monetary policies and underlined the significant intermediary role of depository financial institutions. He developed the computer program of the ARE model in JAVA on the platform of Swarm. Mr. Wei Duan updated China's 2010 input-output table with the intelligent agent technique. Then, he reviewed the fiscal policies, such as carbon tax and other sorts of taxes, and their impacts on the economy, and the method to simulate the fiscal policy. In the computer program, diverse entities in the practical economy were designed as intelligent agents who could negotiate with each other and change their behaviors dynamically according to the environment circumstances. Mr. Mingtao Yao made some modifications on the ARE model. He devoted himself to build the module of the labor market in the model and code-relevant

program, in order to embody the effects of labor issues on the national economy. Besides, he executed some experiments of fiscal policies and monetary policies to test the consequences of various policy packages by virtue of the model. Mr. Jian Zhang improved the ARE model and related computer program, especially in the field of international commodity market to make it more reasonable and realistic and the module of inventory in all the production sector agents to adjust their behavior process. He perfected the approach to calculate the energy consumption and electricity consumption in the model. All the simulations from 2008 to 2025 displayed in this book were conducted by him. Mr. Ning Zhang made some corrections on the computer program to consummate the mechanism and interfaces of the fiscal policies and monetary policies and revised the design of the computer program window and some ideas on improving the program. As the last team member, he was committed to collect and analyze the policy experiment results and summarize all the previous work in the team. And also Dr. Jing Wang, Dr. Wei Ding, Dr. Junjie Kang, Dr. Jinghong Zhou, Ms. Yan Xu, Ms. Chuning Na, and Dr. Yanan Zheng have contributed a lot on the theory and the model when they were doctoral students and postdoctoral from 2003 to 2014.

We are very grateful for the help from a lot of researchers and scholars in a series of discussions on electricity economics and the ARE model. And also Dr. Zhaoguang Hu's presentations on the above issues at Tsinghua University, Massachusetts Institute of Technology, Lawrence Berkeley National Laboratory, Argonne National Laboratory, International Energy Agency, World Bank, and other institutions have been discussed in detail. They have provided us with many beneficial suggestions for our research. We appreciate their time and support a lot. They are listed as follows:

Prof. Huijiong Wang (Development Research Center, the State Council of China), Prof. Xiliang Zhang (Tsinghua University, China), Prof. Yi Wang, Prof. Junyong Wu, Prof. Jinghan He, Prof. Yuhui Zhou (Beijing Jiaotong University, China), Prof. Dongxiao Niu, Prof. Zhongfu Tan, Prof. Huiru Zhao (North China Electric Power University, China), Dr. Dong Wang (Rio Tinto, China), Dr. Bo Shen (Lawrence Berkeley National Laboratory, USA), Dr. Valerie J. Karplus, Mr. Loren C. Cox, Dr. John E. Parsons (Massachusetts Institute of Technology, USA), Dr. Jianhui Wang (Argonne National Laboratory, USA), Dr. Ming Yang (GEF, World Bank), Max Dupuy (Regulatory Assistance Project, USA), Dr. Fuqiang Yang and Ms. Finamore Barbara (Natural Resources Defense Council, USA), Mr. Kevin JianjunTu (International Energy Agency), Prof. Hameed Nezhad (Metropolitan State University, USA), Mr. Zheng Hu (University of Delaware, USA), Mr. Froylan E. Sifuentes (University of California at Berkeley, USA), Mr. Baoguo Shan, and Mr. Xinyang Han (State Grid Energy Research Institute, China).

We would like to express our sincere appreciation to all of them.

Since the knowledge scope of our team is limited, we know that our research cannot be perfect. Accordingly, there may be some mistakes in this book, although we have tried our best to avoid them. It is our will that readers can gain something

after reading the book. More importantly, we look forward to the discussion and even criticisms from the readers, because we believe that truth develops in criticism, while fallacy grows in praise.

Beijing, China
28 February 2015

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http://www.springer.com/978-3-662-47297-2

China's Economic Gene Mutations
By Electricity Economics and Multi-agent
Hu, Z.; Zhang, J.; Zhang, N.
2015, XVIII, 491 p. 285 illus., 277 illus. in color.,
Hardcover
ISBN: 978-3-662-47297-2